3. EVALUATION RESULTS

The four alternatives that were reviewed and moved forward for further investigation include:

1. TP1 – SBR with Chemically Enhanced P-Removal
2. TP7 - Ballasted sedimentation process.
3. TP9 – Coagulation followed by direct filtration.
4. TP10 – Upflow filtration

With the exception of TP1, each of these processes is an add-on to the existing process. General descriptions and advantages and disadvantages of each of the processes are described below. Site specific evaluations of each will be included in the subsequent chapters.

TP1 – SBR with Chemically Enhanced P-Removal

Biological phosphorous removal either in traditional activated sludge basins or in sequencing batch reactors (SBRs) has been accomplished worldwide over the past 20 years. The important components in all the systems include an anaerobic zone or stage for phosphorous removal, possibly an anoxic zone or stage for nitrate removal, and an aerobic zone or stage for BOD and /or ammonia removal.

In the biological removal of total phosphorus, the phosphorus in the influent wastewater is incorporated into cell biomass, which is subsequently removed from the process through wasting of settled sludge. The reactor configuration provides the phosphorus accumulating organisms (PAO) with a competitive advantage over other bacteria so they are encouraged to grow and consume phosphorus. After these bacteria consume phosphorous, the phosphorus enriched sludge is settled and wasted through an aerobic wasting system. Aeration is provided to the wasted solids to ensure that the biologically stored phosphorus remains within the activated sludge.

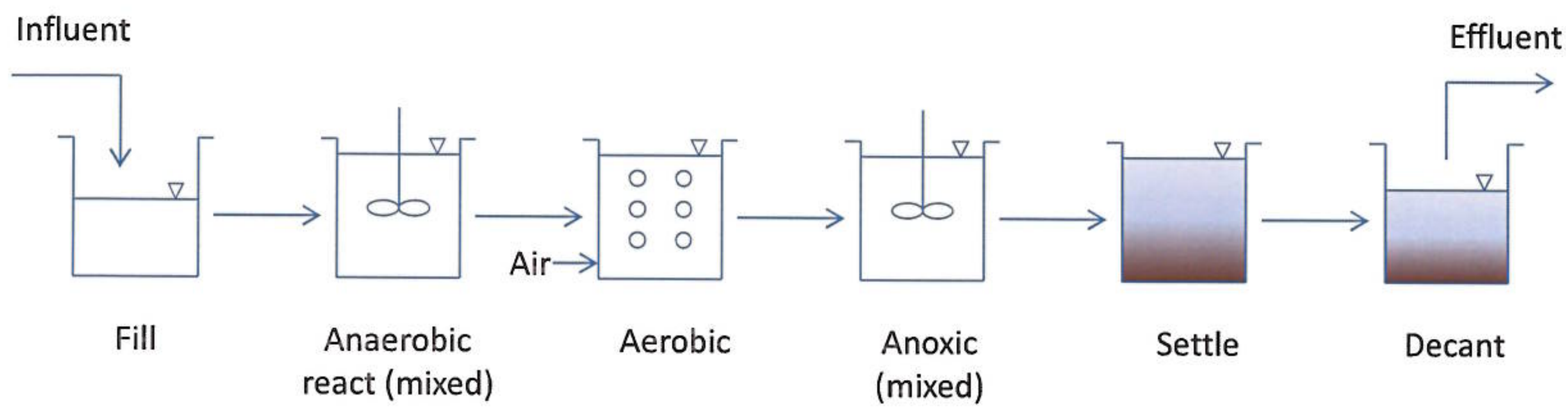
The SBR process is a batch process requiring two or more reactors for a continuous-flow application and involves the following five steps:

- Fill
- React
- Settle
- Decant
- Idle

In the case of Newport, the React stage will consist of an anaerobic period, aerobic period, and an anoxic period. While the effluent requirements for Newport's NPDES Wastewater Discharge Permit include low concentrations of total phosphorus only, an anoxic period during the React stage will be required to consume nitrate and allow for truly anaerobic conditions during the fill and first phase of the React stage. Reducing the nitrate will allow the PAO to use the readily biodegradable COD instead of nitrate-reducing bacteria. Refer to Figure 4-1 for a flow schematic of this process.

It is estimated that the process alone, in combination with a low dose of coagulant, will be able to achieve 70 to 90% total phosphorus removal. Given the effectiveness of the combined chemical and biological treatment processes, it is therefore anticipated that the effluent will contain less than 0.05 mg/L of soluble ortho-phosphorus. However, the decanted effluent will normally contain 10 mg/L or less of suspended solids. Incorporated into these biological solids will be 3 - 6% particulate phosphorus based on typical cellular characteristics. Therefore, up to 0.30 to 0.60 mg/L of particulate phosphorus will be included in the final effluent and thus may exceed the effluent requirement for less than 0.42 mg/L total phosphorus. To remove the particulate phosphorus a filtration process would be required to achieve effluent total phosphorus concentrations of 0.42 mg/L or less. Therefore, this alternative includes the SBR process and a filtration process for phosphorous removal to the current permit limit. This alternative would also easily remove phosphorous to much lower levels and likely meet future permit limitations as well.

The advantage to this type of system is that in addition to removing phosphorous, nitrogen can also be removed from the effluent if the system is properly designed. It brings with it higher operating costs, higher initial construction costs, as well as the remaining need for an additional filtration process for polishing.



AECOM

SBR with Biological Phosphorous Removal - Flow Schematic

Town of Newport, New Hampshire

Figure 4-1

TP7 – Ballasted Sedimentation

Ballasted unit processes were selected for further evaluation because of their proven ability at other locations to achieve the low levels of phosphorus in the effluent. Ballasted sedimentation processes use a ballast material such as microsand, magnetite, or other material plus a coagulant and polymer to add density to the coagulated floc to improve settling and phosphorus removal. Examples of these processes include CoMag, Actiflo, and DensaDeg (use of internal recirculation methods to increase floc density).

The advantages of these systems are that they add on to the existing unit processes with the potential to reduce the capital cost of improvements. The downside is that they are mechanically intensive, use chemicals and polymers to achieve the desired results, may need pre-screening, may not fit well into the hydraulic profile, and do not provide any ability to remove nitrogen if this is required in the future.

Process Example: DensaDeg®

The DensaDeg system uses recycled thickened sludge to add density to the flocculated particles. The system consists of tanks aligned in a certain configuration to which a chemical such as ferric chloride or alum is used as a coagulant. Polymer is added also, and the combined mixture is discharged to a clarifier for settling of the floc. Thickened sludge is recycled, and the waste sludge would need to be processed. The system is proven to reduce phosphorus levels to less than 0.42 mg/l.

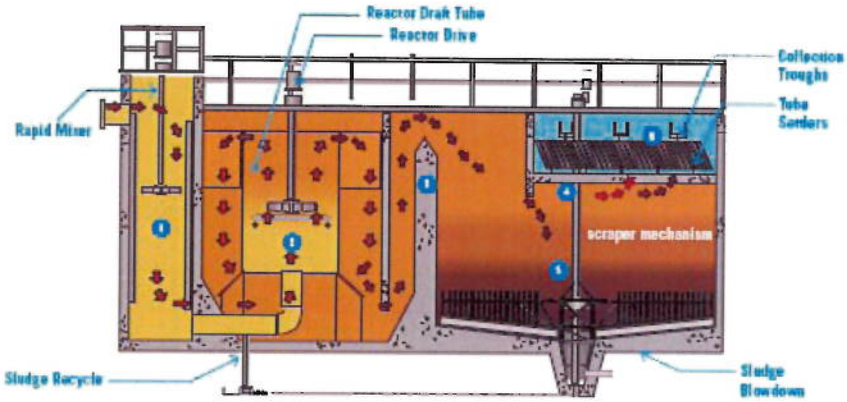


Figure 4-2 DensaDeg® Process Schematic

Process Example: Kruger Actiflo®

The Actiflo system uses microsand to add density to the flocculated particles. The system consists of tanks aligned in a certain configuration to which a chemical such as ferric chloride or alum is used as a coagulant. Polymer is added also, and the combined mixture is discharged to a clarifier for settling of the floc. Sand is recycled via a hydrocyclone, and the sludge is pumped to the solids processing system. The system is proven to reduce total phosphorus levels to less than 0.2 mg/l. There are five United States installations using this system for phosphorus removal over the past 3-7 years, and thirty installations internationally.

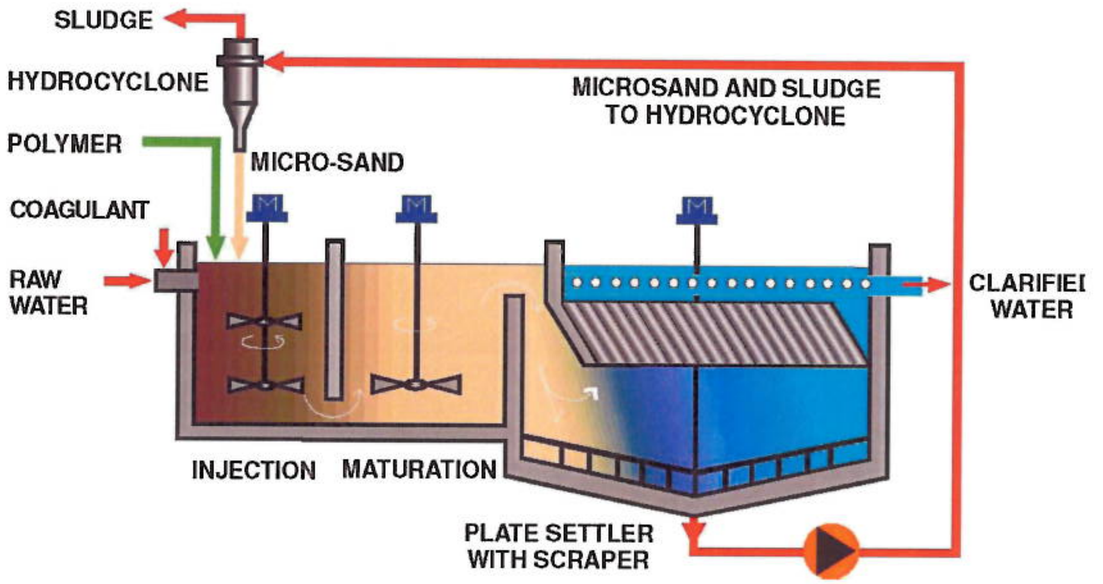


Figure 4-3 Actiflo® Process Schematic

TP9 – Coagulation Followed by Direct Filtration

Coagulation and filtration processes are well proven to remove phosphorus to low levels. This process is viable for removal of phosphorus to 1.0 mg/l without filters and to less than 0.2 mg/l when filters are used. Chemical precipitation is used to remove the inorganic forms of phosphate by the addition of a coagulant and a mixing of wastewater and coagulant. The multivalent metal ions most commonly used are aluminum or iron. This process requires a mixing device and clarification or filtration. Filtration can be accomplished using single or dual media filters or cloth media filters.

The advantages of these systems are similar to those of ballasted sedimentation processes. They add on to the existing unit processes and have the potential to reduce the capital cost of improvements but they are mechanically intensive, use chemicals and polymers to achieve the desired results, may need pre-screening, may not fit well into the hydraulic profile, and do not provide any ability to remove nitrogen if this is required in the future.

Single or Dual Media Filters

There are various combinations of single or dual media filters, however generally they all direct the flow of water down or up through sand or anthracite media. The particles are trapped in the media and removed. Once head loss becomes excessive, the filter is taken out of service and cleaned.

The cleaning requires a back wash system using pumped final effluent that carries the trapped particles out of the media and recycles the sludge to the head of the treatment plant. The back wash rate for most of these types of filters ranges from 5 - 8% of the incoming flow. This technology has been utilized for several decades.

The concern with media filters relates to the algae in a lagoon system. Algae species number in the hundreds, and range in size upward from 1 micron in diameter. A concern with these systems is that the media would pass the smaller algae species, and plug hydraulically with the larger species. This would increase the size and complexity of the media system and hence its cost. With cloth media filtration available, media filtration would not be considered acceptable for a lagoon effluent.

Cloth Media Filters

Cloth media filters are a relatively new process development compared to media filters and have the advantage of requiring a much smaller footprint than media filters and significantly less mechanical and power requirements. Cloth media filters generally consist of a hollow frame covered with a synthetic cloth material and supported on a rotating shaft. The core of the frame provides an area which collects the filtered effluent once it has passed through the 10 micron media and then pipes this filtered effluent out to the final discharge. When the cloth media becomes plugged with solids, the rotating frame drive is activated and water is drawn backwards through the media via a small suction head, pipe work and a pump. A small portion of the cloth is taken out of service during the cleaning and approximately 3% of the incoming flow is utilized for backwash.

The advantage of the cloth media filter is the simple operation, reduced backwash flow, smaller site footprint, and significantly reduced capital and operating costs. Cloth media filters are viable for phosphorus removal and as a final polishing step to an SBR or other activated sludge process provided they are able to effectively remove algae.

TP10 – Upflow filtration

Upflow filtration technologies filter, absorb and adsorb phosphorous. These systems use a coagulant such as ferric or alum and occasionally a polymer. Coagulation takes place within the filter so a separate coagulation tank is not required. Examples include DynaSand and BluePro. The advantages of these systems are similar to those of ballasted sedimentation processes. They add on to the existing unit processes and have the potential to reduce the capital cost of improvements but they are mechanically intensive, use chemicals and polymers to achieve the desired results, may need pre-screening, may not fit well into the hydraulic profile, and do not provide any ability to remove nitrogen if this is required in the future.

Process Example: DynaSand® Parkson

The DynaSand® process is a physical and chemical treatment process, which combines co-precipitation and filtration. The technology uses an automatically cleaning up-flow filter for solids removal. The filter has continuous flow, which allows constant operation without having to shut down for backwashing.

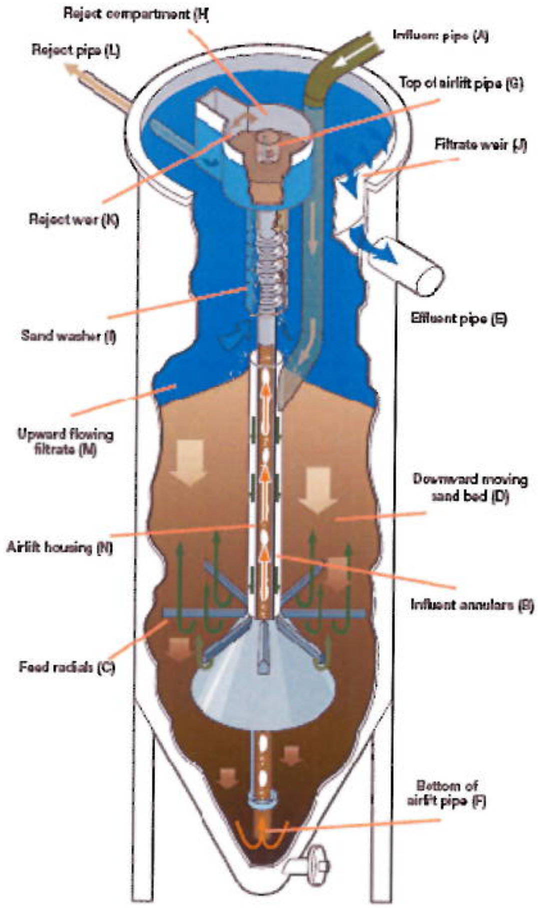


Figure 4-4 DynaSand® Process Schematic

Conclusions

Moving forward, the workshop team decided to pilot three of the preferred phosphorous removal processes described above and to review all of them in greater detail. The processes selected for pilot testing were TP7 – Ballasted sedimentation (the least complex ballasted sedimentation process, DensaDeg, was piloted). TP9 – Coagulation followed by direct filtration with cloth media, and TP10 Upflow filter. TP1 – SBR with chemically enhanced P-removal was not selected for pilot testing because it is a well understood and proven process for phosphorus removal.

Results of the pilot testing will be discussed in the next chapter.

C. NITROGEN AND PHOSPHOROUS REMOVAL ALTERNATIVES

After narrowing the list of potential phosphorous removal technologies, the workshop participants followed a similar process to identify technologies that will remove both nitrogen and phosphorous. AECOM was asked to examine potential nitrogen removal technologies because the ultimate discharge location for the Sugar River is the Connecticut River, and downstream communities have needed to address nitrogen limits. The sections below outline the evaluation process completed at the workshop.

1. TREATMENT TECHNOLOGIES FOR REVIEW

Many of the operational and technical concerns that are important to the phosphorous removal portion of the project are also important for nitrogen and phosphorous removal. The list of these concerns generated for nitrogen removal processes is shown below.

1. Nitrogen removal design to less than 8 mg/l is the target based on Long Island Sound TMDL. The process needs to be flexible for potential future lower limits;
2. Sustainability;
3. Low temperature operation;
4. Process designed for 1.3 million gallons per day (plant treatment capacity);
5. No increase in odors;
6. Low influent pH;
7. Minimize chemical use;
8. Unknown nutrient loading speciation;
9. Algae growth;
10. Ease of maintenance;
11. Redundancy;
12. Lagoon structural issues;
13. Manual solids processing;
14. Rehabilitate septage handling;
15. Upgrade UV disinfection;
16. Utilize automated process control to allow unattended operation.

After this discussion, the workshop participants identified various processes for nitrogen removal.

The full range of ideas included:

1. TN1 – Eliminate lagoons and install an SBR process sized for nitrogen and biological phosphorus removal plus chemically enhanced P-removal
2. TN2 – Convert lagoons to flow-through activated sludge process with secondary clarifiers and chemically enhanced P-removal.
3. TN3 – Cover lagoons, add air, and convert a portion to a denitrification zone with methanol addition. Use chemically enhanced P-removal in the lagoons.
4. TN4 – Submerged Attached Growth Reactor with chemically enhanced P-removal in the lagoons.
5. TN5 – Install a Biological Aerated Filter (BAF) after the lagoons and subsequent P-removal.

2. EVALUATION PROCESS AND RESULTS

All processes were presented and discussed with the group. The only process that met with approval by the group for future study was TN1 – SBR with chemically enhanced P-removal. Other flow through activated sludge processes would perform equally as well.

The reasons for dropping the others from consideration are listed below:

1. TN2 – Process control will be difficult in large lagoons. Very labor intensive and difficult to maintain.
2. TN3 – There is very little operating experience with this type of process. Risk to meeting potential permit limits is significant. Chemical dependent, and would be difficult to attain lower levels if needed.
3. TN4 – Very little large scale operating experience with this type of process. Risk to potential permit limits is significant. Limited in effluent quality that can be attained.
4. TN5 – Will be very expensive to implement and involves complex operation, chemicals and automated controls. Can accomplish the same goals with fewer unit processes.

D. GROUNDWATER DISCHARGE ALTERNATIVES

The advantage of discharging effluent to the groundwater, instead of directly to surface water is that the discharge levels of total phosphorus, certain metals and other monitored constituents become less stringent. The standards are less stringent because the constituents are attenuated in the soils and/or groundwater, supplementing treatment that may be required prior to discharging directly to surface water. This in-ground treatment can result in fewer upgrades to a treatment plant as well as saving in treatment costs.

Groundwater discharges would need to meet DES regulations as contained in Section Env-Wq 402, the most important of which include the need for secondary treatment, the need for nitrogen treatment to 10 mg/l nitrate to meet ambient water quality standards, and the requirement that there be two year travel time to any well intake. Guidelines published by the DES are contained in the New Hampshire Code of Administrative Rules ENV-WS-1500 and WD-03-31 contains the information and regulations pertaining to groundwater discharges.

A groundwater discharge of treated wastewater can take place through several methods. The most common methods of discharge are through Rapid Infiltration Basins (RIBs) and leaching fields. The RIBs, also known as rapid infiltration systems, are open beds located at the ground surface. Leaching trenches are generally installed just below the ground surface. Benefits of RIBs are that they require less land area for an equivalent discharge rate. This is due to RIBs being allowed to discharge at a higher loading rate per square foot. RIBs are also accessible from the ground surface should maintenance be required.

Benefits of leaching trenches are that they are out of sight and can be used in areas where RIBs cannot be considered (golf course fairways, open space parcels, parks, etc.). With leaching trenches, odors are generally less of an issue and routine maintenance is generally not required.

Groundwater discharges may not be viable if soils with adequate transmitting capacity are not present. As part of our scope, AECOM researched soil types across Newport. Several sources were researched to evaluate the soils types in the vicinity of Newport. These sources include the following:

- US Geological Survey (USGS) – Online and in house reports
- New Hampshire Department of Environmental Services (DES) Online Records
- New Hampshire State Geologist Web Site
- US Department of Agriculture (USDA) Natural Resources Conservation Service soils maps - Online
- Federal Emergency Management Agency (FEMA) Flood Insurance Maps - Online

To date, no detailed quadrangle scale surficial geology maps have been published by the USGS for the Newport area. However, areas of stratified-drift aquifers are identified in a USGS paper titled Groundwater Resources in New Hampshire: Stratified-Drift Aquifers (Medalie and Moore, 1995). According to Medalie and Moore, a significant area of stratified-drift aquifer has been deposited in the Newport area. This aquifer is mapped in a north-south direction, generally following Route 10 from Newport's northern town line with Croyton to its southern town line with Unity and Goshen. According to their paper, the most favorable aquifer has been mapped in the vicinity of the Town's existing water supply north of Corbin Road and in the vicinity of the Little Red Schoolhouse Museum near Route 10 and Pollards Mills Road.

According to the USDA's Natural Resources Conservation Service, soils mapping of this area generally confirms the presence of the stratified-drift, along Route 10. In general, these soils are described as being very deep, well- to excessively well-drained with high to very high saturated conductivity. The most common soils mapped along this stratified drift corridor are of the Adams, Colton, Haven, and Herman series.

As part of our review, AECOM researched soils mapping for two Town owned parcels. Both parcels were identified as potential groundwater discharge locations by the Town. These Town owned parcels are listed on the Assessors Maps as:

- Parcel 3 on Map 227 - 11.4 acre parcel
- Parcel 37 on Map 226 - 19 acre parcel

General:

According to the USGS and the Natural Resources Conservation Services mapping, both parcels are underlain by sand and/or sand and gravel aquifer soils. In general, these soils have the potential to transmit significant quantities or groundwater which may make them suitable for a groundwater discharge. However, according to the 1955 USGS Sunapee Quadrangle Map, both parcels are located adjacent to the Sugar River and appear to be in relatively low-lying areas. Due to the topographic scale of the USGS map being in 10 foot vertical contours, it is difficult to evaluate the ground surface relative to the adjacent river. However, based on the topographic maps, groundwater may be within 10 feet of the ground surface, potentially limiting the discharge capacity of the parcels.

The FEMA Flood Insurance Maps appear to confirm the USGS Topographic mapping in that significant portions of both parcels fall within the Sugar River's flood plain. This not only indicates that portions of these properties may be under water during a significant flood, but also that groundwater may be relatively close to the ground surface. There is no topographic information available that would confirm this.

Water Supply:

There are no maps indicating the direction of groundwater flow. Due to the proximity of the parcels to the Sugar River, groundwater most likely flows towards the river. The Town's water supply is located over 4,500 feet north of Parcel 3. Parcel 37 is located on the opposite side of the Sugar River. The Town's water supply is approximately 2,500 feet to the southwest. The location of the parcels with respect to the existing water supply makes it very unlikely that the groundwater discharge would have any effect on the existing water supply wells. However, if either of the two parcels in question were used for wastewater discharge, the parcel use for future public water supply would be compromised.

Since the discharge would likely flow to the river, there would be no requirement for a 2-year travel-time between the discharge and a public water supply. The travel time only applies to groundwater discharges that flow directly to a groundwater water supply. An evaluation of potential impacts to the Town's water supply as well, as any private water supplies, would be part of the detailed hydrogeologic investigation required by DES.

Size of RIB's

An initial evaluation of the acreage necessary to discharge the design flow of the treatment plant (1.3 MGD) was performed. The estimate is very preliminary as the NHDES formula for calculating RIB acreage requires input that can only be obtained through a hydrogeologic investigation. However, by using ranges for the unknown input values, a sense of acreage necessary can be obtained.

The acreage of parcels 3 and 37 are 11.4 and 19 respectively, for a total of 30.4 acres. To discharge the design flow of 1.3 MGD and still have room for access roads, piping, and valve structures, the soils underlying the parcels would need to have the ability to accept wastewater flow rates at relatively high loading rates. In other words, the soils underlying the parcels would need to be a relatively coarse sand and/or sand and gravel and underly the entire parcel, to discharge the design flow within the 30 acres available. It is unlikely that only one of the sites will be sufficient to accept the entire 1.3 mgd flow.

Wastewater treatment:

The advantage of an in-ground discharge is that the total phosphorus discharge level (as well as other monitored constituents) becomes less important because the wastewater is discharged to the ground and many of the monitored parameters are attenuated by the soils or there is dilution that can be used to meet the discharge limits at the limit of the groundwater discharge zone. Discharges would need to meet NHDES regulations as contained in Section Env-Wq 402 and 310 the most important of which, from a treatment perspective, include the need for secondary treatment and the need for nitrogen treatment to 10 mg/l nitrate to meet ambient water quality standards.

The advantage of this option is that phosphorus removal to low levels at the treatment plant would likely not need to be practiced because of assimilation in the soil. Disinfection is not practiced for subsurface discharges as well. Limited ammonia data is available at the treatment plant but the information that is available indicates that ammonia in the influent is at least 15 mg/l on average. This value generally becomes nitrate during the lagoon treatment process during those times when the lagoon nitrifies. Therefore, additional wastewater treatment including denitrification would need to be provided to ensure that ambient water quality standards, especially for nitrates, are met at the groundwater discharge zone boundary. The lagoons do not provide this level of treatment and would not be able to be retrofitted to be able to provide this. It is possible that dilution levels may be high enough to meet the water quality standards at the boundary, but a full hydrogeological study would be needed to confirm this.

If pursued as a viable alternative, a hydrogeological study and other testing would need to be performed to verify loading rates, dilution and assimilation capacities. The capital cost of this option would consist of the following:

- Construction of multiple infiltration basins;
- Pumping station consisting of pumps, foundation, building, electrical and instrumentation systems;
- Force main piping and distribution system.
- Miscellaneous yard piping modifications;
- Treatment plant upgrade for nitrogen removal during periods of nitrification;

Evaluation

At this time, there have been no efforts by others to establish or confirm the soil types, thickness of overburden soils, or depth to groundwater at either parcel. Based on our review of available data, it appears that Parcels 3 and 37 would not be adequate to discharge the entire 1.3 MGD. The most limiting factor appears to be that both parcels likely have a high water table which will reduce the loading rate and that significant portions of the parcels may be susceptible to flooding which would eliminate the possibility of discharge in those areas.

From a non-monetary perspective, issues that need to be accepted for ground discharge include contamination of a potential water supply site, permanent groundwater monitoring, and likely treatment for nitrate control. Based on these factors it is not suggested to pursue this option further.

If however, the Town decides to pursue the groundwater discharge option, the first step would be to assess the topography of the parcels through a site visit. If the topography appears to be favorable for a discharge, the next step would be to excavate several test pits at each location to determine soils types. If necessary, soil borings may need to be drilled and monitoring wells installed to estimate the water table depth and aquifer thickness.

After these investigations, if one or both of the parcels appear to be favorable for a groundwater discharge, a more detailed hydrogeologic investigation would be required by DES to confirm the soil types, the soil's transmitting capacity, the depth to groundwater, the groundwater flow direction, groundwater mounding and the discharge capacity of each parcel. The Town may also want to consider other parcels for the discharge, as a large area of favorable soils have been mapped along the Route 10 corridor.

References:

Medalie, Laura and Moore, Richard Bridge, "Groundwater Resources in New Hampshire: Stratified-Drift Aquifers", Water-Resources Investigations Report 95-4100.

5. PILOT STUDY RESULTS

A. PILOT SET-UP

1. Technologies

As mentioned in Chapter 4, there were several phosphorous removal technologies that the workshop participants moved forward for further evaluation. Among those, two technologies were pilot tested. Brief summaries of the ballasted sedimentation process and coagulation followed by direct filtration were presented in Chapter 4. The Infilco Degrement DensaDeg® unit was selected as representative of the ballasted sedimentation process and the Kruger International Hydrotech Discfilter® (Discfilter®) was selected as representative of the coagulation followed by direct filtration process. The sections below summarize the pilot protocol, schedule, testing, and results.

2. Sampling Protocol and Schedule

The pilot study was scheduled to start operation on Monday, November 2, 2009 and was designed to operate for a duration of three weeks, ending on Friday, November 20, 2009. The piloting was scheduled to coincide with lagoon operations which were considered to be the most problematic from an operational perspective. Table 5-1 below summarizes the activities planned for each of the days during the pilot schedule.

Table 5-1: Original Pilot Study Schedule

Daily Activity and Objective Schedule	
Day 1: November 2, 2009	Mobilization, Set-up, Electrical and Plumbing Hook-ups
Days 2-4: November 3, 2009 November 4, 2009 November 5, 2009	Coagulant: Aluminum Sulfate Objective: Meet a Consistent Phosphorous Effluent of 0.35 mg/L
Days 5-7: November 6, 2009 November 9, 2009 November 10, 2009	Coagulant: Aluminum Sulfate Objective: Achieve Maximum Phosphorous Removal
Day 8: November 11, 2009	Coagulant: Transition from Aluminum Sulfate to Ferric Chloride Objective: Meet a Consistent Phosphorous Effluent of 0.35 mg/L
Days 9-11: November 12, 2009 November 13, 2009 November 16, 2009	Coagulant: Ferric Chloride Objective: Meet a Consistent Phosphorous Effluent of 0.35 mg/L
Days 12-14: November 17, 2009 November 18, 2009 November 19, 2009	Coagulant: Ferric Chloride Objective: Achieve Maximum Phosphorous Removal
Day 15: November 20, 2009	Pilot Unit Breakdown and Demobilization

Due to the delivery schedule of chemicals on-site and delivery of pilot units, the sequence of operations was modified to use ferric chloride first for the Discfilter®. The objectives were also revised to achieve maximum phosphorous removal at the beginning or piloting in order for the pilot operators to determine the optimal coagulant dose. This optimal dose would then be used to achieve a Total Phosphorous effluent limit of 0.35 mg/L (permit limit is 0.42 mg/L).

Due to prior commitments, travel time, and extensive set-up time, the Densadeg® unit was not able to meet this original schedule. Table 5-2 below presents the revised final schedule for both Discfilter® and Densadeg®. In an effort to obtain as much side by side results as possible, the protocol for the Densadeg® pilot was revised to start testing using aluminum sulfate and finish using ferric chloride. The Discfilter® protocol was then modified to pilot starting with ferric chloride and ending with aluminum sulfate. The Densadeg® pilot test was also shorter than the Discfilter® pilot due to a longer mobilization and set-up period, time to develop a sludge blanket, and the Thanksgiving holiday.

Table 5-2: Pilot Study Schedule - Revised

NOVEMBER 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2 Kruger Discfilter: Arrived & Set-up	3 Kruger Discfilter: Optimization	4 *Day 1 Sample* Coagulant: Ferric Obj: Max TP Removal	5 Kruger Discfilter: Shutdown for Day IDI DensaDeg: Arrival & Set-up	6 *Day 2 Sample* Coagulant: Ferric Obj: Max TP Removal IDI DensaDeg: Set-up	7 IDI DensaDeg: Set-up
8	9 *Day 3 Sample* Coagulant: Ferric Obj: Max TP Removal IDI DensaDeg: Set-up	10 *Day 4 Sample* Coagulant: Ferric Obj: Consistent TP = 0.35 mg/L IDI DensaDeg: Set-up (Sludge Blanket)	11 *Day 5 Sample* Coagulant: Ferric Obj: Consistent TP = 0.35 mg/L IDI DensaDeg: Set-up (Sludge Blanket)	12 *Day 6 Sample* Coagulant: Ferric Obj: Consistent TP = 0.35 mg/L IDI DensaDeg: Set-up (Sludge Blanket)	13 *Day 7 Sample* Coagulant: Alum Obj: Max TP Removal	14
15	16 *Day 8 Sample* Coagulant: Alum Obj: Max TP Removal	17 *Day 9 Sample* Coagulant: Alum Obj: Max TP Removal	18 *Day 10 Sample* Coagulant: Alum Obj: Consistent TP = 0.35 mg/L IDI DensaDeg: Ferric Slude Blanket Forming	19 *Day 11 Sample* Coagulant: Alum Obj: Consistent TP = 0.35 mg/L	20 *Day 12 Sample* Coagulant: Alum Obj: Consistent TP = 0.35 mg/L Kruger: Breakdown	21
22	23 *Day 13 Sample* Coagulant: Ferric Obj: Max TP Removal	24 *Day 14 Sample* Coagulant: Ferric Obj: Max TP Removal	25 NO TESTING - THANKSGIVING	26	27	28
29	30 IDI DensaDeg: Breakdown	1	2	3	4	

October 2009

S	M	T	W	Th	F	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

December 2009

S	M	T	W	Th	F	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Notes:

- Kruger Discfilter
- IDI DensaDeg
- Both Units

Operational information was collected on a daily basis. This data included:

- Flow (gpm)
- Loading rate (gpm/sf)
- Total Phosphorous
- Dissolved Phosphorous
- Orthophosphate
- Total Suspended Solids (TSS)
- Biochemical Oxygen Demand (BOD)
- Ammonia, as Nitrogen
- Total Aluminum
- Turbidity
- pH
- UV_{254} Transmittance
- Alkalinity

This data was collected for both influent and effluent flow streams. Water quality data was collected and sent to a certified analytical laboratory for analysis. Table 5-3 provides a summary of water quality parameters that were analyzed and the frequency of sample collection. All samples tested by the certified analytical laboratory were composite samples. Composite samples were collected once per hour during the work day. Pilot unit influent samples were taken from the chlorine contact basin and were common for both pilot units. Note that ammonia was measured at the influent to the entire treatment plant to provide information on influent ammonia.

The lab that performed the analyses is Eastern Analytical, Inc. (800-287-0525).

Table 5-3: Water Quality Parameters Tested by Certified Laboratory

Parameter	Analysis by Certified Laboratory	Frequency Per Pilot unit
Total Phosphorous	SM 4500	1/ day
Dissolved Phosphorous	SM 4500	1/ day
Reactive Phosphorous	SM 4500	1/ day
Total Suspended Solids	EPA 160.2	1/ day
Biochemical Oxygen Demand	EPA 405.1	1/ day
Ammonia[1]	SM 4500	1/ day
Total Aluminum	EPA 200.7	1/ day
Turbidity	EPA 180.1	1/ day
pH[2]	EPA 150.1	1/ day
UV_{254}	SM 5910 B	1/ day
Alkalinity	EPA 310.2	1/day

SM – Standard Methods
EPA – Environmental Protection Agency
1 – Plant influent
2 – by WWTF staff

B. PILOT TESTING

1. Kruger International Hydrotech Discfilter®

The Discfilter testing took place from November 2 - 19. The unit arrived on Monday, November 2, 2009 and was successfully up and running to begin sampling on Tuesday, November 3, 2009. The pilot unit was set up with all the tanks and discfilter on a platform with an enclosed laboratory. Set-up consisted of connecting potable water for backwash, pumping from the chlorine contact tanks to the unit, setting up the discharge piping, and providing 480-volt/70 Amp electrical service. Once these elements were connected, the unit was ready to begin testing.

The testing began using ferric chloride and Hydrex 6161 polymer to achieve 0.35 mg/L effluent total phosphorus and later switched to aluminum sulfate to reach the same goals. All of the tests performed were daily extended runs. For the most part, different coagulant doses were used each day to try and maintain 0.35 mg/L effluent total phosphorus.

The first few days were dedicated to optimizing the ferric chloride (ferric) dose to achieve maximum effluent total phosphorus removal as well as find a dose that would maintain an effluent total phosphorus level of 0.35 mg/L. Each day 6-7 hourly samples were taken to form composite sample in which no parameters were changed (coagulant dose, polymer dose, etc.).

The last five days of testing were performed using aluminum sulfate (alum) as the coagulant. Again chemical doses were changed once per day and were run for a period of 24 hours and composite samples were created from hourly grab samples taken during normal operating hours. The goals were the same as with the ferric chloride to achieve maximum effluent total phosphorus removal as well as find a dose that would maintain an effluent total phosphorus level of 0.35 mg/L.

After coagulant optimization was reached, hydraulic loading rate curves were conducted using the 10μm filter panels. Loading rate curves were conducted using ferric chloride (ferric) and aluminum sulfate (alum) at loading rates of 2.0, 3.0, and 3.5 gpm/ft^2 (33, 50, and 58 gpm). At each parameter change, samples were collected for effluent total phosphorus. The influent total phosphorus was collected as a composite sample. The polymer dose stayed constant at 1.0 mg/L. The ferric dose was kept constant at 60 mg/L (based on previous data trying to achieve 0.35 mg/L effluent total phosphorus). At each change in hydraulic loading rate, chemical drawdowns were conducted for coagulant and polymer.

The last testing that occurred was similar to the aluminum sulfate loading rate curve except the filter panels were switched from 10μm to 40μm.

This test was performed to see if static times would improve and if the same total phosphorus removal would be achieved at the same operating parameters as the 10μm filter panels.

2. **Inflico Degremont DensaDeg®**

The Inflico Degremont DensaDeg® unit arrived on Thursday, November 5, 2009. This unit arrived with significant mechanical work to be completed before the unit was operational.

The DensaDeg® pilot unit was not skid mounted equipment because of over-the-road height restrictions and therefore required extensive set up and a significant amount of effort on the part of the operations staff to assist in set-up. This delayed set-up time.

Once the unit was set-up, the pilot unit required a minimum of three days to develop a sludge blanket. This needed to be done twice – once for each coagulant. This minimized the amount of sampling and operating time for the IDI unit. With weather being a major cause for concern, the Newport operations staff did not want the IDI unit to be on-site much later than the Thanksgiving holiday because the unit was not enclosed, and freezing pipes and equipment were factors that needed to be taken into consideration, especially over the weekend and holidays when the IDI staff was not attending to the pilot unit.

Once the unit was operational, the first days of each phase (Aluminum Sulfate and Ferric Chloride) of the study were used to determine the optimal coagulant and polymer doses required to treat the raw water to the 0.35 mg/L effluent Total Phosphorous goal. The DensaDeg® has a retention time, based only on the flow, between 18 and 72 minutes. Therefore, changes made to the coagulant and polymer dose were allowed 2 to 3 hours to stabilize.

The loading rate across the DensaDeg® lamellar area is directly proportional to flow. Therefore, as the flow to the pilot increases, the DensaDeg® loading rate increases. The pilot has a hydraulic capacity of approximately 200 gpm and was operated at flow rates of 58 to 90 gpm, yielding 5.5 to 8.5 gpm/ft^2 over the course of the piloting period.

C. PILOT RESULTS

1. Certified Laboratory Results and On-site Testing Results

With few exceptions, samples tested by the certified analytical laboratory were time based composite samples collected approximately once per hour during the work day, and then sent to Eastern Analytical, Inc. for analysis. The results of this sampling are presented in Table 5-4 - Phosphorous Removal Pilot Study Results.

On-site testing was used by the pilot manufacturers to optimize their pilot operations. These tests were performed by a hand-held Hach instrument and corroborated with the treatment plant lab. Some of this data was then used to support conclusions in their report, however, these on-site results would not include some of the phosphorus that is tied up in organic form, and we noted that when on-site results were compared to certified lab results, that the on-site testing always showed a lower phosphorus result. The samples sent to the Certified Laboratory were composite samples, and while these may include some start-up variances in the first morning sample, were collected every hour during the day of sampling and are considered more representative than on-site testing.

2. Manufacturer's Results

AECOM requested that both manufacturers develop a Pilot Study Report and a full-scale design proposal as part of the pilot study. These documents included the following topics to allow AECOM to evaluate the pilot study's performance:

- Objectives of pilot study and report;
- Description of the pilot unit and process;
- Description of pilot unit operations (flow, coagulant, loading rate etc.);
- Sludge/waste/residuals production description;
- Pilot performance results;
- Conclusions;
- Proposed Full-scale design;
    - Flow rates
    - Loading rates
    - Dimension and number of units (including redundancy)
    - Determination of coagulant
    - Chemical dose and use requirements
    - Waste production